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IDENTIFICATION OF SEVEN SPECIES OF PEROMYSCUS FROM TRANS-PECOS TEXAS BY CHARACTERS OF THE LOWER JAWS

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Field parties from Midwestern State University recently obtained a large collection of mammal remains from Pleistocene and early Recent deposits in a cave in southern Culberson County, Texas. Identification of the remains of *Peromyscus* from the cave presented major problems because seven species of this genus occur in Culberson County today (Schmidly, 1977), and specimens of four species were trapped within a few hundred yards of the cave mouth. An eighth species, *Peromyscus crinitus*, is found in western New Mexico and has been reported from cave deposits in Eddy County, New Mexico, only 100 miles to the north.

Other workers have encountered this same problem. Harris (1974) listed five species of *Peromyscus* (including *P. crinitus*) from Dry Cave, Eddy Co., New Mexico. Logan and Black (1977), working with *Peromyscus* from Upper Sloth Cave, in northern Culberson County, Texas, referred upper molars lacking styles and lophs in the major valleys to *P. eremicus* and those of all other specimens to "*Peromyscus* sp." Lundelius (1977), who studied a collection of subfossil bones from Pratt Cave in northern Culberson County, referred jaws with large teeth to *P. difficilis* and those of all other specimens of the genus to "*Peromyscus* sp."

Because our collection from southern Culberson County included a quantity of relatively well-preserved lower jaws, we examined specimens of all species of Recent *Peromyscus* of concern to determine if characteristics of the lower jaws would permit identification on that basis alone.

In fossil *Peromyscus* jaws from cave deposits, mandibular rami are the bones most commonly found; coronoid and articular processes and the angle of the jaw often are broken away and some teeth frequently are missing. The third molar is most often lost and the first most often present. Characters normally of practical value, therefore, are those of the ramus (Fig. 1) and lower first molar (Fig. 2).

Because geographic variation is, or may be, marked in some of the characters used, we confined our work to Recent material from Trans-Pecos Texas and immediately adjacent areas in New Mexico. Whenever possible, we used specimens from Culberson County, but were forced to use some material from adjacent counties or even farther away. Only for *Peromyscus truei* and *P. difficilis* did we depend on specimens from New Mexico.

Some of the characters used could be detected only in teeth in slight to moderate stages of wear. Young specimens—those with more than a small amount of the gray or bluish immature pelage—were rejected, as were aged mice with the enamel pattern of m1 worn flat or nearly so. Field collectors often tend to save the large and brightly colored individuals taken in their traps, and this bias results in large numbers of old to senile individuals preserved in collections. We had to search the collections of Midwestern State University, Texas Tech University, and Texas A&M University to obtain adequate series of some species. In the case of *Peromyscus truei*, only four suitable animals were available. We found that dentitions of specimens of *P. truei* from farther west, within the main geographic range of the species, appeared markedly different in some respects from the four specimens from Texas and eastern New Mexico, the eastern extremity of the range. Therefore, we have listed our findings for these four individuals only.

Details of the enamel pattern of the first lower molar were determined using a dissecting microscope; all measurements were made with an ocular micrometer. Specimens were chosen from museum trays until an arbitrary number of 28 jaws at the proper stage of tooth wear were found. Sex of specimens was disregarded inasmuch as it cannot be determined from fossil jaws.

We found characters of major value to be as follows: the nature of the incisor-base capsule, alveolar length of the lower molar row, and details of the enamel pattern m1.

Incisor-base capsule.—The proximal end of the lower incisor in *Peromyscus* is enveloped in the permanent enamel-forming organ and dental epithelium. The organ lies at the level of the masseteric crest on the labial margin of the ramus. The bone swells slightly to greatly at this point to form a thin-walled, bony capsule containing the enamel-forming organ. We rated the capsule in three grades. In Grade O there is only a slight labial bulge at the site of the enamel-forming organ when the jaw is seen from directly above, with coronoid process and labial side of the jaw held on the same plane. In lateral view, the capsule is seen to rise only slighly to moderately above the masseteric crest, and only the dorsal outline of the capsule is distinct. The postero-dorsal margin merges imperceptibly with the jaw ramus. In Grade 1, the capsule makes a strong bulge when seen from above, and in lateral view both dorsal and posterior margins are well marked. The bone of the posterior margin is not recessed, however, and there is no true groove outlining the posterior margin. In Grade 2, the capsule is recessed on both dorsal and posterior margins, so that a blunt, fingerlike projection is formed; the masseteric crest is strongly distorted in lateral view.

Length of molar row.—Because some teeth often are lost in fossil *Peromyscus* jaws, we depended on the alveolar length of the toothrow. Measurements were taken on the lingual side, with the jaw slightly tilted, so that the margins of the alveoli were visible.

Length and breadth of first lower molar.—The m1 of *Peromyscus* is somewhat bulbous, reaching maximum diameter well below the top of the crown of the unworn tooth. When the tooth is worn below this level, measurements, especially of length, are deceptively small and become still smaller with additional wear. Maximum occlusal surface is exposed quite early in life, not long after the adult pelage is in place.

The first lower molar was viewed from the lingual side, perpendicular to the lingual surface of the ramus. If the anterior edge of m1 thus shown did not disclose an inward curve at the top, the maximum occlusal surface was not yet exposed and the specimen was rejected. In specimens of the proper age, measurements were taken from the anteriormost point of the anterior curvature of the tooth to the vertical line of contact with m2. Breadth of m1 was measured at the broadest point of the talonid.

Anteroconid of first lower molar.—Typically, the anteroconid of m1 of *Peromyscus* bears a slight notch or groove on the anterdorsal surface of the unworn tooth. This notch is often absent

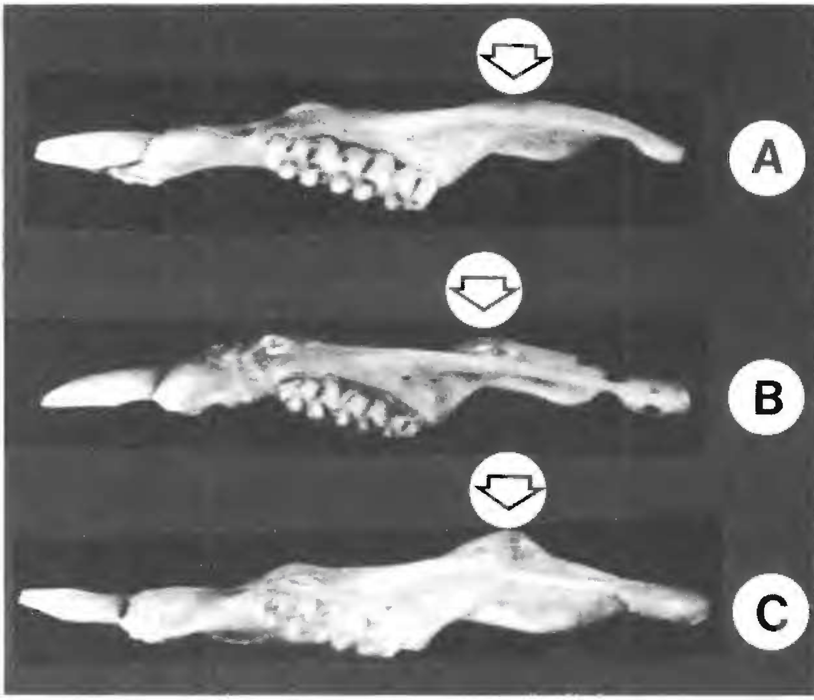

FIG. 1.—Dorsal view of *Peromyscus* jaws, displaying grades of bulge of the incisor-base capsule (arrows). A is Grade 0, B is Grade 1, and C is Grade 2.

and even when present, may be so shallow that it is worn away in early stages of attrition; this we consider Grade O. In some species the notch, though narrow, is persistent and moderately deep until rather late stages of moderate tooth wear; this is Grade 1. In Grade 1, the groove is so narrow that there is little or no space between the enamel surface. In Grade 2 there is a distinct valley separating the anteroconid into inner and outer parts. This valley, with the valley between anteroconid and metaconid, may give the trigonoid a trefoil or clover-leaf appearance.

Lophids and stylids.—Hooper (1957) made a detailed study of lophs, styles, lophids, and stylids in *Peromyscus*. This work involved structures of all teeth, including elevated structures visible only under high magnification. Cornely *et al.* (1981) treated the dental patterns of *Peromyscus* in their study of these mice in Guadalupe Mountains National Park, Culberson Co., Texas. We have confined our observations to the stylids and lophids blocking the two major valleys of the m1—ectosylid, mesostylid, ectolophid, and mesolophid.

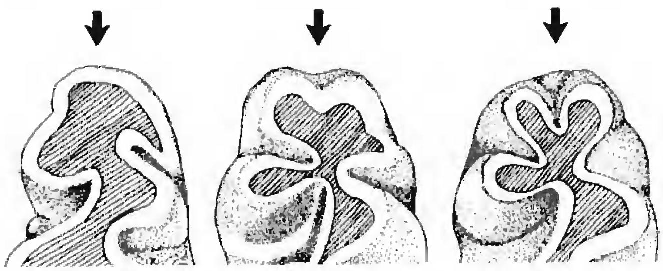

FIG. 2.—Dorsal view of occlusal surface of right lower m1 from *Peromyscus*, displaying grades of division of anteroconid (arrows).

We have counted as stylids only those cusps prominent enough to be seen in lateral view with a 10-power lens. We did not count the small projections or roughnesses that sometimes occur in the length of a valley, but only stylids that were large enough to block partially or completely the mouths of the valleys. A low but often sharp-edged cingulum sometimes closes the mouth of a valley. If this cingulum was level along its crest, it was not counted as a stylid, even if faint to moderate grooves separated the structure from the walls of adjacent cusps. If the structure was separated from the walls of adjacent cusps by distinct valleys, it was considered a stylid, even if it was not actually a pointed cusp. In most instances, however, stylids counted were conical structures with one distinct point or several closely grouped tiny points at the apex.

Lophids were counted if they were distinct enamel folds reaching out from the body of the tooth into a major valley, regardless of whether they were elevated to the level of the triturating surfaces of the tooth or lay at a lower level in the valley. Mere wrinkles and deflections of the enamel were not counted.

Lophids sometimes had a constricted area near the termination of the fold and thus might have been considered a lophid plus a stylid. In such cases, we counted only the lophid. More rarely a lophid had an elevated area on the crest of the fold and thus also might have been considered a lophid plus a stylid, although this would be obvious only in early stages of wear. We disregarded these accessory stylids also.

In our treatment, a major valley could have only one structure present—a stylid or a lophid. Thus, m1 might have the following possible combinations: neither stylids or lophids, one stylid, two stylids, one stylid and one lophid, one lophid, or two lophids.

Other characters.—Other characters showed some promise as criteria for identification of species and were considered, but are not documented here in detail. For example, multiplying length by breadth of m1 gave a crude approximation of the area of the occusal surface of the tooth. We did this for the seven species of *Peromyscus* from Culberson County, but the results obtained were essentially the same as obtained from the length of m1 alone.

Dalquest *et al.* (1969) found that the tendency to develop isolated lakes helped to separate *Peromyscus "boylii"* from *P. pectoralis* on the Edwards Plateau of Texas. The taxon considered *P. boylii* in that work has since been accorded full specific status as *P. attwateri* (Schmidly, 1973). The lower dentition of *P. attwateri* is extremely different from that of *P. boylii* from Trans-Pecos Texas. Development of isolated enamel lakes in the lower molars is not strong in the species of *Peromyscus* found in Southwestern Texas and is a transient feature, obvious only at later stages of wear. The lakes are rarely detectable in specimens as young as those used in this study.

Dalquest *et al.* (1969) also separated *Peromyscus maniculatus* from *P. leucopus* on the Edwards Plateau by the length of m1-m2. In the jaws from the cave in southern Culberson County, few individuals had both of these teeth present, so we did not study this feature.

The development of the third lower molar also may prove to be important in identification, but few of our fossil jaws contained this tooth.

CHARACTERIZATION

Tables 1 and 2 reveal that overlap in characters studied made it difficult to identify positively a single lower jaw to species in many instances. In most features, however, the overlap between some species was slight, resulting from one or two variant individuals. Given a large series of lower jaws of mixed species of *Peromyscus* from Trans-Pecos Texas, use of combinations of characters often made it possible to determine whether or not a species was present, to identify some individual jaws to species, and to narrow the identification of other jaws to one of two species. Fossils from late Pleistocene age cave deposits frequently include quantities of presumably mixed species of *Peromyscus,*

TABLE 1.—*Development of incisor-base capsule, division of anteroconid of first lower molar, and development of stylids and lophids in first lower molar of seven species of* Peromyscus *(N=28 except for* P. truei *where* N=4*).*

	maniculatus	*leucopus*	*eremicus*	*boylii*	*pectoralis*	*difficilis*	*truei*
Incisor capsule 0	0 (0%)	0 (0%)	11 (39%)	28 (100%)	28 (100%)	28 (100%)	4 (100%)
Incisor capsule 1	10 (36%)	1 (4%)	11 (39%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Incisor capsule 2	18 (64%)	27 (96%)	6 (21%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Anteroconid 0	22 (79%)	28 (100%)	23 (82%)	12 (43%)	1 (4%)	3 (11%)	2 (50%)
Anteroconid 1	6 (21%)	0 (0%)	5 (18%)	15 (54%)	10 (36%)	3 (11%)	1 (25%)
Anteroconid 2	0 (0%)	0 (0%)	0 (0%)	1 (4%)	17 (61%)	22 (79%)	1 (25%)
No stylids	24 (86%)	25 (89%)	14 (50%)	20 (71%)	4 (14%)	4 (14%)	3 (75%)
With stylids	4 (14%)	3 (11%)	14 (50%)	8 (29%)	24 (86%)	24 (86%)	1 (25%)
Ectostylids	1	1	5	6	9	3	1
Mesostylids	3	2	9	1	10	5	0
Total stylids	4	3	14	7	19	8	1
No lophids	26 (93%)	28 (100%)	20 (78%)	27 (96%)	5 (18%)	5 (18%)	3 (75%)
With lophids	2 (7%)	0 (0%)	8 (29%)	1 (4%)	23 (82%)	23 (82%)	1 (25%)
Ectolophids	1	0	7	1	17	20	1
Mesolophids	1	1	3	0	11	19	0
Total lophids	2	1	10	1	28	39	1

TABLE 2.—*Measurements (mm.) of lower dentition in seven species of* Peromyscus.

	maniculatus (N=28)	*leucopus* (N=28)	*eremicus* (N=28)	*boylii* (N=28)	*pectoralis* (N=26)	*difficilis* (N=28)	*truei* (N=28)
			Length m1-m3				
Minimum	3.42	3.55	3.55	3.65	3.65	4.10	3.85
Maximum	4.00	4.15	3.95	4.20	4.10	4.70	4.20
Mean	3.74	3.87	3.72	3.93	3.89	4.36	4.05
SD	0.14	0.18	0.13	0.12	0.12	0.14	0.16
			Length m1				
Minimum	1.40	1.50	1.50	1.65	1.65	1.85	1.75
Maximum	1.75	1.85	1.75	1.85	1.85	2.05	1.85
Mean	1.63	1.66	1.61	1.73	1.71	1.94	1.80
SD	0.09	0.08	0.07	0.05	0.05	0.06	0.06
			Breadth m1				
Minimum	0.90	1.00	0.90	1.00	0.95	1.10	1.05
Maximum	1.15	1.10	1.10	1.10	1.15	1.35	1.10
Mean	1.01	1.03	1.10	1.06	1.04	1.17	1.08
SD	0.06	0.03	0.04	0.03	0.05	0.06	0.05

and any means of separating the collection may yield important information as to past distribution, paleoecology, and climatic conditions at the collecting sites. The data here assembled permit characterization of the species studied as follows.

Peromyscus maniculatus.—Incisor-base capsule always strongly to moderately well developed; anteroconid usually not divided (79% Grade 0); stylids and lophids uncommon to rare (14% and 7%, respectively).

Peromyscus leucopus.—Incisor-base capsule always strongly developed; anteroconid almost never divided; stylids uncommon (11%) and lophids absent.

Peromyscus eremicus.—Extremely variable; incisor-base capsule Grade 0 in about a third (39%) of the series; anteroconid usually not divided (82%) and if divided not strongly so; stylids present in about half of the first lower molars, lophids present in about a third (29%).

Peromyscus boylii.—Incisor-base capsule always Grade 0; anteroconid divided in about half the jaws, but usually not deeply so; stylids present in about a third (29%) of the jaws but lophids usually absent.

Peromyscus pectoralis.—Incisor-base capsule always Grade 0; anteroconid almost always divided, usually deeply so; stylids and lophids usually present (86% and 82%).

Peromyscus difficilis.—Size large, alveolar length of m1-m3 greater than 4.1 mm.; incisor-base capsule always Grade 0; anteroconid usually divided (90%); stylids and lophids usually present (86% and 82).

Peromyscus truei.—The following is based on only four specimens. Mice examined from Arizona and westward had teeth so different from those of the four individuals from the eastern edge of the geographic range of this species that we did not include them in the study. Size larger than all species except *P. difficilis;* incisor-base capsule Grade O; anteroconid divided in half the jaws; stylids and lophids each present 25 per cent of the time.

Peromyscus crinitus.—This species is not included in the tables because we have no evidence that it ever occurred in Texas, although it is found today as far as the western-central border of New Mexico and Harris (1974) included *P. crinitus* in the fauna from Dry Cave, Eddy County, in that state. His listing is queried, but apparently on chronologic rather than taxonomic grounds. This is a distinctive species, as seen from specimens examined from Arizona and Utah. Size small, alveolar length of m1-m3 3.0 to 3.5 mm.; incisor-base capsule strongly developed but small in diameter; anteroconid not divided; stylids and lophids absent. One is more apt to confuse a lower jaw of this mouse with one of *Reithrodontomys* rather than with that of another species of *Peromyscus.*

Identification

The strongly developed incisor-base capsule serves to separate *Peromyscus maniculatus* and *P. leucopus* from all other Trans-Pecos members of the genus except *P. eremicus. P. eremicus* had a well-developed capsule in more than two-thirds of the specimens examined. *P. leucopus* averages larger than *P. maniculatus* and *P. eremicus,* but there is broad overlap in the alveolar length of m1-m3. A character helpful in separating *P. leucopus* from *P. maniculatus* and *P. eremicus* is the size of the occlusal surface of the anteroconid. In *P. leucopus,* the surface is usually a large, broad, tilted plane extending back to the metaconid and protoconid. In the other two species, it is usually smaller and narrower. Although readily apparent to the eye, this feature is difficult to measure. The absence of lophids in the m1 of *P. leucopus* is also helpful. A jaw with a well-developed incisor-base capsule and with lophids might be *P. maniculatus* or *P. eremicus* but not *P. leucopus.* If a lophid and a stylid are present in m1, the jaw is probably *P. eremicus.* Although most *P. leucopus* and some *P. eremicus* can be selected using characters mentioned above, many specimens, probably including most of the *P. maniculatus,* cannot be positively identified.

Hooper (1957), in his detailed studies of the accessory structures in *Peromyscus* molars, commented on the simplicity of the teeth of *P. eremicus.* This alleged simplicity (absence of lophs, stylids, lophids, stylids) has been mentioned by later writers, and even used as a key character in identification. However, Hooper's remarks were not intended to be thus taken. His tables and figures show that accessory structures do occur in *P. eremicus,* that they vary geographically, and that they are more common in Texas than to the west and south. We found that in Trans-Pecos Texas stylids occur in about half of the lower first molars of *P. eremicus* and lophids in almost a third. On the other hand, *P. leucopus,* shown by Hooper (1957) to have moderately complicated teeth in parts of its geographic range, has extremely simple teeth in Trans-Pecos Texas.

Of the jaws lacking the well-developed incisor-base capsule, *Peromyscus difficilis* is identifiable by extreme alveolar length of m1-m3 (greater than 4.1 mm.) and by a deeply divided anteroconid and presence of stylids and lophids on m1. It is possible, however, that some large *P. truei* might be difficult to separate from small *P. difficilis.*

Peromyscus pectoralis and *P. boylii* are similar in size. In Texas, these species are sometimes sympatric and, were it not for the dark ankles of *P. boylii* and white ankles of *P. pectoralis,* freshly taken individuals would be difficult to separate. The lower m1 is diagnostic, however, because *P. pectoralis* has a deeply divided anteroconid, and stylids or lophids (or both) are almost invariably present. In *P. boylii,* the enamel pattern is simple—the anteroconid divided only about half of the time, stylids uncommon, and lophids almost always absent.

Those *Peromyscus eremicus* that lack the well-developed incisor-base capsule (less than one-third of the individuals examined) may be difficult to separate from *P. pectoralis* and *P. truei. P. eremicus* is smaller (jaws with alveolar length of m1-m3 greater than 3.95 mm. would not be *eremicus*), the anteroconid when divided is not deeply so (thus contracting with 60% of *P. perctoralis* teeth), and lophids are commonly present (20% as contrasted with only 4% in *P. boylii*).

General Application

We compared species from Trans-Pecos Texas with specimens of the relevent species from various localities in the United States and Mexico. Some of the characters, such as the nature of the incisor-base capsule have broad application. Other characters may be subject to considerable geographic variation, although most (except in *Peromyscus eremicus*) are relatively stable in any geographic area. Before the characters here discussed can be applied to a collection of jaws of mixed species of *Peromyscus*, the characteristics of those taxa occurring at or near the collecting site should be ascertained.

Features that serve to separate species in one area may or may not do so elsewhere. For example, we found that *Peromyscus maniculatus blandus* from Trans-Pecos Texas averaged smaller than *P. leucopus tornillo* from the same area, but measurements overlapped so broadly that alveolar length of m1-m3 was of little value in separating the two. In contrast, there is a broad zone in central Texas where *P. m. pallescens*, a diminutive race, occurs together with *P. l. texanus*, a robust-bodied race. In this area, the two species can be separated by size alone.

Culberson County, Texas, where any of eight species of *Peromyscus* could occur in a late Pleistocene fauna, is a special case. Our study reveals that identification would be greatly simplified in a collection of jaws from a locality where *P. eremicus* is not expected.

Properly used, the lower jaw ramus and first lower molar are of value in identifying specimens of *Peromyscus* to species, but only when used with care. Some of the *Peromyscus* jaws from later Pleistocene deposits that are identifed to species in the literature should be accepted only with caution.

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